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WIDEBAND TEST AND EVALUATION FINAL REPORT

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The performance of seven wideband (16 kb/s or greater) coders was tested and evaluated for comparison of recently developed speech coders with speech coders based on the continuously variable slope delta (CVSD) algorithm. The CVSD coder at 32 kb/s was superior to the other coders at 16 kb/s. Under nontactical conditions on some tests the APCQ speech coder was superior to the CVSD at 32 kb/s. Under tactical conditions the CVSD coder was superior to other 16 kb/s speech coders.

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WIDEBAND TEST AND EVALUATION

FINAL REPORT

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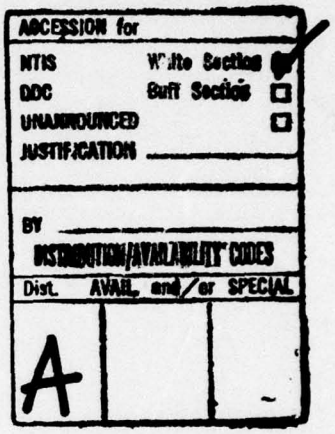

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FOREWORD

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I. INTRODUCTION

1. PURPOSE

The purpose of the wideband test and evaluation was to determine and compare the performance of certain wideband speech coders. Wideband refers to a transmission data rate of 16 kb/s or greater. It was desired to evaluate the performance of recently developed wideband speech coders and compare them with speech coders based on the continuously variable slope delta (CVSD) algorithm. Improved wideband speech coders have potential application to the Defense Communications System. The test conditions represented a wide range of operating environments similar to those of the Narrowband Consortium T&E [1]. Speech coder performance was measured with respect to speech quality and intelligibility. The overall performance of the speech coders was compared and the sensitivity of the speech coders to various operating conditions was evaluated.

2. SCOPE

A complete set of tests was performed for seven different speech coders. Each coder was an implementation of a specific speech coding technique. These algorithms are continuously variable slope delta (CVSD) modulation, adaptive delta modulation (ADM), adaptive residual coding (ARC), and adaptive predictive coding (APC). In the following sections each device is briefly described.

a. CVSD-B COD 16. This CVSD speech coder was designed and built by Codex Corp. The algorithm was designed to produce optimal speech quality under conditions of bit error rates less than 5%. The operating data rate was 16 kb/s. A detailed description of this device is contained in the Codex final report [2]. An analysis of the performance sensitivity of the CVSD speech coder with respect to the algorithm parameters is presented in the report [3].

b. COD ARC 16. This speech coder was designed and built by Codex Corp. The algorithm is based on adaptive residual coding (ARC). The operating data rate is 16 kb/s. A detailed description is contained in [2].

c. COD ADM 16. This speech coder, which was also designed and built by Codex Corp., is based on the adaptive delta modulation (ADM) algorithm. The operating data rate is 16 kb/s. A detailed description is also contained in [2].

d. SCHIL 16/3. This CVSD speech coder is based on the so called Schilling algorithm. The operating data rate is 16 kb/s. The bandwidth of the audio output filter is approximately 3 kHz.

e. SCHIL 32/4. This device is similar to the coder described above except that the operating rate is 32 kb/s and the audio bandwidth is 4 kHz.

f. SYLM APCQ 16. This speech coder was implemented on the Sylvania Programmable Signal Processor. The coding algorithm was designed by GTE Sylvania and is based on APC with an adaptive multilevel quantizer. The operating data rate is 16 kb/s. A detailed description of this speech coder is contained in the Sylvania final report [4].

g. LOG CVSD 16. This device is based on the CVSD algorithm and was built by General Dynamics. The operating data rate is 16 kb/s.

3. TEST CONDITIONS

The speech coders were evaluated with respect to simulated operational conditions. These conditions are divided into the following groups:

a. Optimal Condition. This condition is intended to represent an ideal operating environment with an input speech signal having a high signal to noise ratio and low distortion level. In addition, there were no transmission bit errors and an attempt was made to adjust the audio input level to an optimal setting for each speech coder.

b. Acoustic Background Noise. Test tapes were used which contained speech data recorded under conditions of acoustic background noise. These tests included three acoustic background noise conditions: (a) office noise, (b) airborne command post (ABCP) noise, and (c) helicopter noise.

c. Transmission Bit Errors. This test condition consisted of injecting bit errors into the transmission data stream. The probability of the occurrence of a bit error is based on a normal distribution. Bit error rates of 1% and 0.1% were used. Bit errors were produced by an error generator that produced a pseudo-random binary sequence.

d. Dynamic Range. The audio input level of the speech coder was adjusted in order to measure the effects on the performance of the coder. Measurements were made to determine the optimal audio level of each speech coder and this was defined as the reference level of 0 dB. To test dynamic range, performance was evaluated for audio input levels of +6 dB, -12 dB, and -20 dB.

e. Tandem Operation. This test condition was designed to measure the performance of speech coders in multiple link configurations and in tandem with a narrowband speech coder. Multiple link tandem tests on two, three, and five-link configurations were performed. The operation of each speech coder in tandem with a linear predictive coder (LPC) was tested. The LPC speech coder was operating at a data rate of 2.4 kb/s.

4. MODEM TESTING

A set of tests were conducted in order to evaluate effects of processing MODEM link signals with a CVSD speech coder operating at 32 kb/s. The results of this testing are discussed in Appendix A.

II. BACKGROUND

1. NARROWBAND CONSORTIUM T&E

In May 1976, the final report of the Narrowband Digital Voice Consortium was published. The objective of the consortium was to recommend a narrowband speech algorithm that could be adopted to satisfy operational needs of DoD for secure voice on narrowband transmission media such as HF radio, switched telephone networks, and satellites. Equipment from the following generic classes of voice processors designed for narrowband channels were tested and evaluated:

- o Adaptive Residual Coder (ARC)
- o Adaptive Predictive Coder (APC)
- o Linear Predictive Coder (LPC)
- o Channel Vocoder (CV)
- o Hybrid Speech Coder (TRIVOX).

The test program was managed by the T&E Subcommittee under the chairmanship of DCA and was for the most part performed at the DCA Hybrid Simulation Facility with NRL performing the HF and simulated satellite test. Performance evaluation was performed using both intelligibility and quality tests. Intelligibility was measured using the Diagnostic Rhyme Test (DRT) and the Consonant Recognition Test (CRT). Quality was measured using the Paired Acceptance Rating (PAR). The narrowband voice processor operated at data rates from 2.4 kb/s to 9.6 kb/s. The LPC-10 algorithm was recommended in the Consortium final report as the DoD standard for narrowband speech processing.

2. PERFORMANCE EVALUATION

The wideband speech coder performance evaluations were based on intelligibility and quality tests. The Diagnostic Rhyme Test (DRT) has been found to be a reliable procedure for measuring word intelligibility [5]. The DRT was used for the wideband evaluations, and these scores can be compared with the results of the Narrowband Consortium T&E [1]. The DRT does not necessarily give a valid measure of the overall performance of a speech coder. Specifically, high DRT scores do not necessarily imply high user acceptance. For this reason speech quality evaluations were also conducted.

The purpose of the quality evaluations was to determine the overall user acceptance of the speech quality of each coder. The Diagnostic Acceptability Measure (DAM) was the procedure selected to accomplish the quality evaluations [6]. The DAM is an evaluation method designed to eliminate many of the inconsistencies associated with the Paired Acceptability Rating Method (PARM) that was used in the Narrowband Consortium T&E. Both the DAM and DRT employ listeners who record subjective responses

for evaluation. Therefore, there is a significant degree of error associated with each method; the DRT scores generally have a smaller standard error than the DAM scores.

Evaluation results should be interpreted carefully with the knowledge that user preference is difficult to quantify. Corresponding to each DAM score is an equivalent PARM score so that these results can be compared with the Narrowband Consortium T&E. Figure I is a plot that shows the estimated relationship between DAM scores and user acceptance.

3. TEST PROCEDURES

The speech data that was evaluated according to the intelligibility and quality tests was stored on audio magnetic tape. These tapes were prepared in the same laboratory facility used for the Narrowband Consortium T&E [1]. A description of the test facilities is contained in the Consortium Final Report. As in the Narrowband Consortium T&E, the magnetic tapes were given to Dynastat Corp for intelligibility and quality evaluations.

III. TECHNICAL DISCUSSION

1. COMPARISONS OF SPEECH CODER PERFORMANCE

The results of the intelligibility and quality tests were analyzed to determine the statistical significance of differences in system DRT and DAM scores. As in the Narrowband Consortium T&E, the Neuman-Kuels test [7] was used to rank systems and estimate the statistical significance of system scores. The results are grouped according to test conditions. The test results are displayed in the form of a table containing a matrix which is used to compare a set of speech coders under a given operating condition. Alongside the matrix are listed the speech coder mean score, standard error, names, and identification numbers. Above the matrix is shown the system identification numbers. The systems are ranked in order of decreasing test scores. The system rank order corresponds to the matrix row number. The numbers in the matrix above the main diagonal are the differences between system mean scores; the (i,j) element, where j is greater than i, is the difference in mean scores between the system ranked i and the system ranked j. For example, in Table II, the number 1.6, row 2 and column 4 is the difference between the score 93.4, of the system ranked number 2 (CVSD ARC 16).

The Neuman-Kuels test is a systematic procedure for determining the statistical significance in the difference between these mean scores. Below the main diagonal are numbers that represent the confidence levels of the difference between system mean scores. For example, a confidence level of 0.99 implies that the probability is 0.01 or less that the system scores are samples from the same probability distribution. Therefore, the confidence level is 0.99 that the difference in scores is statistically significant. The (i.j.,) element, where i is greater than j, is the confidence level corresponding to the difference in scores between the system ranked i and the system ranked j. The scores were evaluated for three confidence levels, 0.99, 0.95, and 0.90; no entry in the matrix indicates that the confidence level is less than 0.90. For example, in Table II, the confidence level of the difference in mean scores between COD ARC 16 and SCHIL 32/4 is 0.99; between COD ARC 16 and CVSD B COD 16 it is 0.90; and between COD ARC 16 and SYLM APCQ 16 the confidence level is less than 0.90. This implies that there is not a high level of confidence that the mean scores of CVSD B COD 16 and SYLM APCQ 16 are significantly different.

a. Optimal Conditions. Table II shows the DRT scores and statistical test results corresponding to six male speakers under optimal conditions. As noted previously, optimal conditions correspond to a quiet acoustic background with no transmission bit errors. As expected, the test results show that the performance of SCHIL 32/4 was better than all the other

speech coders operating at 16 kb/s. It can also be seen that this superior performance is statistically significant. The LOG CVSD 16 was significantly poorer than any other technique on this test. Based on the performance of this technique under the other conditions tested and on the DAM score for optimal condition, this score is 15 points lower than expected. This low score is attributed to a misadjustment in the input audio level which is particularly critical for this technique. Lower than expected DRT scores also occurred with LOG CVSD 16 for test conditions of 1% BER and LPC into LOG CVSD 16.

It can be seen from Table II that the results of the Neuman-Kuels analysis can be used to group the test results in terms of statistical significance. Examination of the first column of confidence levels in Table II indicates that the difference between the score achieved by SCHIL 32/4 and the other techniques is great enough to indicate a true difference in performance. Examination of the second column in Table II indicates that the difference between the score achieved by CVSD B COD 16 and SYLM APCQ 16 is not great enough to indicate a true difference in performance (first entry in the column is blank). Differences in score between CVSD B COD 16 and the remaining techniques, however, are great enough to indicate a true difference in performance as indicated by the presence of the confidence level scores. The statistical significance of the differences in the scores for the remaining techniques can be determined by examining the remaining columns in a similar fashion.

Table III shows the DAM results corresponding to two male speakers under optimal conditions. The correspondence between the DAM scores and estimated user acceptance can be found in Figure 1. It can be seen that SCHIL 32/4 had the highest overall score and SYLM APCQ 16 had the best score among the 16 kb/s coders.

Table IV contains the DRT results corresponding to three female speakers. CVSD B COD 16 and SYLM APCQ 16 had the best DRT scores among the 16 kb/s coders. Table V contains the DAM results corresponding to one female speaker. It can be seen that based on this test the DAM scores are divided into two groups. SYLM APCQ 16 and SCHIL 32/4 are in the first group and the remaining coders are in the second group.

In summary, under optimal test conditions the Sylvania APC algorithm (SYLM APCQ 16) had the best overall performance of the 16 kb/s algorithms.

b. Background Noise Conditions

(1) Office Noise. Table VI contains the DRT results for one male speaker under conditions of an office noise environment. It can be seen from these results that several 16 kb/s coders performed as well as SCHIL 32/4. Table VII contains the DAM results corresponding to three male speakers.

Table VIII contains the DRT results corresponding to one female speaker. In this test COD ADM 16 scored as well as SCHIL 32/4. In Table IX the DAM results corresponding to one female speaker are given.

(2) Airborne Command Post Noise. The DRT and DAM results for airborne command post background noise are shown in Tables X and XI respectively. These results are based on male speakers, and it can be seen that the scores are generally several points lower than the scores for office background noise.

(3) Helicopter Noise. Table XII contains the DRT results for male speakers under conditions of helicopter background noise. It can be seen that the DRT scores are considerably lower than those under optimal conditions. In addition, the statistical test showed that there is no significant difference between any of the systems including SCHIL 32/4. Table XIII contains the results of the voice quality analysis for three male speakers. These scores are quite low, indicating a very small percentage of user acceptance. Also, it can be seen that there is no significant difference in DAM scores except for CVSD B COD 16 which had the lowest score.

c. Transmission Bit Errors. Tests performed under conditions of transmission bit errors are valuable because the corresponding results indicate the expected speech coder performance on actual transmission media. Most transmission media degradations can be shown to correspond to certain transmission bit errors. These bit errors can be divided into two categories, burst errors and normally distributed random errors. The test results of this report are based on random errors derived from a normal probability distribution.

(1) BER of 0.1%. The performance of speech coders such as CVSD whose design is based on delta modulation does not degrade significantly under conditions of relatively high transmission bit error rates. Table XIV shows the DRT results for male speakers corresponding to a BER of 0.1%. For all the speech coders, except LOG CVSD 16, there is only a small difference in DRT scores compared with optimal conditions. Table XV contains the DAM results for male speakers. These results are also similar to those for the optimal conditions. Tables XVI and XVII contain the DRT and DAM results respectively for female speakers. These results indicate that SYLM APCQ 16 performed better than all other 16 kb/s speech coders under this BER condition.

(2) BER of 1%. Table XVIII contains the DRT results for male speakers under conditions of 1% BER. The CVSD B COD 16 performed as well as SCHIL 32/4 in this test. Table XIX contains the speech quality test results for male speakers. Tables XX and XXI contain the DRT and DAM results respectively for one female speaker. The DAM results indicated no statistically significant difference between systems for the female speaker.

d. Audio Input Level

(1) 6 dB Input Level. Speech intelligibility and quality tests were conducted to measure the performance sensitivity of the speech coders with respect to audio input levels. In a realistic operating environment audio input levels will not necessarily be adjusted for optimal performance due to such factors as variability of speakers and microphones. Consequently, it is useful to have an indication of the performance sensitivity to audio levels. Table XXII contains the DRT results corresponding to one male speaker and an audio input level 6 dB above the estimated optimal level. Because these results represent one male speaker, it is not meaningful to compare them with the results of Table II which represent six male speakers. However, the large difference in the DRT score of LOG CVSD 16 indicates that the audio level for the optimal condition test was not set properly. Generally the DRT scores are high with no statistically significant difference between systems except for SCHIL 16/3 which was ordered with the lowest score. The speech quality test results for male and female speakers are shown in Tables XXIII and XXIV respectively. In these tests the user preference for SYLM APCQ 16 is approximately the same as for SCHIL 32/4.

(2) -12 dB Input Level. Table XXV shows the DRT results for one male speaker corresponding to an audio input level 12 dB below the estimated optimal level. Table XXVI shows the DAM results for male speakers. In this speech quality test SYLM APCQ 16 and CVSD B COD 16 performed as well as SCHIL 32/4. In Table XXVII it can be seen that for one female speaker SYLM APCQ 16 performed better than all other speech coders with respect to speech quality.

(3) -20 dB Input Level. Table XXVII contains the DRT results for one male speaker under conditions of an input level 20 dB below the estimated optimal level. Tables XXIX and XXX contain the DAM results for male and female speakers respectively. It can be seen that on the speech quality tests the performance of SYLM APCQ 16 is superior to all other speech coders.

e. Tandem Configurations. Tests were conducted to determine the performance of speech coders in certain tandem configurations. A single transmission link is defined as two identical speech coders connected together such that there is an analog to digital conversion followed by a digital to analog conversion. Multiple tandem links are defined as several single links of identical speech coders connected in series. A wideband-narrowband tandem is the series connection of a single wideband link and a narrowband link.

(1) Multiple Links. Tests of multiple link tandems were conducted for two, three, and five links. Tables XXXI and XXXII contain the DRT and DAM results respectively for male speakers under the condition of two links in tandem. For female speakers the DRT and DAM results are shown in Tables XXXIII and XXXIV respectively.

The DRT and DAM results are shown in Tables XXXV and XXXVI respectively for male speakers under the condition of three links in tandem. Table XXXVII contains the DAM results corresponding to one female speaker. It can be seen that the performance of SYLM APCQ 16 was the lowest of all speech coders tested.

Table XXXVIII contains the DRT results corresponding to five links in tandem for one male speaker. In this test the performance of CVSD B COD 16 was superior to the other 16 kb/s speech coders. Tables XXXIX and XL show the results of the speech quality tests for male and female speakers respectively. It can be seen that speech quality is degraded significantly under conditions of five links in tandem.

(2) Wideband-Narrowband Tandem. The full-duplex tandem operation of wideband and narrowband speech coders was evaluated. The narrowband terminal was a linear predictive coder (LPC) using ten predictor coefficients and operating at a data rate of 2.4 kb/s. A detailed description of this narrowband speech coder is given in reference [8]. Tables XLI and XLII show the DRT and DAM results respectively for male speakers corresponding to LPC tandemed with the wideband speech coders. These results indicate no significant difference in performance between speech coders except for LOG CVSD 16. Tables XLIII and XLIV contain the DRT and DAM results respectively for female speakers. These results also indicate no significant difference in the performance of the speech coders except for COD ADM 16.

The intelligibility and quality results shown in Tables XLV and XLVI respectively represent the performance of the wideband speech coders operating into LPC with male speakers. The DRT and DAM results for female speakers are shown in Tables XLVII and XLVIII respectively. Overall, the best performance of the 16 kb/s speech coders was achieved by SYLM APCQ 16.

f. Summary of Results. The results of the statistical analyses show clearly that the Schilling CVSD coder operating at 32 kb/s is superior in performance to the other speech coders operating at 16 kb/s. Certainly this result is expected. In order to compare the performances of the 16 kb/s speech coders, the ranking of each speech coder for each operating condition is presented in Table XLIX. This table shows the relative ranking corresponding to intelligibility tests for male speakers. The ranking is based on the results of the Neuman-Kuels analyses. System scores are grouped according to the 0.90 confidence level and the groups are then ordered. For example, under optimal conditions in Table XLIX, both SYLM APCQ 16 and CVSD COD 16 are ranked in the first group. For the male DRT, the Codex CVSD speech coder has the best scores over almost all conditions. The Sylvania APCQ ranks very high except for the multiple link tandems. Table L lists the ranking of the 16 kb/s speech coders according to DAM scores for male speakers. Both SYLM APCQ 16 and CVSD B COD 16 are generally superior to the other speech coders under most conditions. Table LI lists the ranking of speech coders based on DRT scores for female speakers. These results indicate that SYLM APCQ 16 is generally superior in performance to the other speech coders. The ranking of systems according to DAM scores for female speakers is shown in Table LII. These results also indicate that SYLM APCQ 16 is generally

superior to the other speech coders.

Certain operating conditions are associated primarily with the tactical communications environment. These are helicopter and airborne command post background noise, high bit error rate, and certain tandem connections. Under the nontactical conditions, the Sylvania APCQ algorithm provides the best performance of the speech coders operating at 16 kb/s. Under the tactical conditions, the Codex CVSD speech coder provides the best performance overall.

2. INTELLIGIBILITY AND QUALITY TEST SCORES

The individual intelligibility and quality test scores are presented in this section so that the performance of each speech coder can be evaluated under all test conditions. These test results indicate how the performance of each speech coder is affected by certain operating conditions and speakers. These results should not be used exclusively to compare the performance of different speech coders. The statistical analyses described in the previous section were performed in order to make such comparisons.

a. Codex CVSD B. Table II lists the DRT scores obtained for the Codex CVSD speech coder operating under the conditions shown. The initials of the male speakers are LL, RH, CH, PK, JE, and BV; the initials of the female speakers are JS, LS, and MP. The standard error of each DRT is shown to the right of the score. For some conditions more than one DRT has been performed, and all scores are listed in the table. These results show that the Codex CVSD speech coder produces highly intelligible speech under almost all operating conditions. Table LIV lists the quality scores resulting from the DAM test. These results indicate that the user acceptance of the Codex CVSD is generally high. However, some inconsistencies in the DAM test are revealed in these results. For example, the scores under 0.1% BER are much lower than under the optimal conditions, although it is known that the effect of 0.1% BER is barely perceptible compared with optimal conditions.

b. Codex ARC. The DRT scores of the ARC speech coder are shown in Table LV. These scores indicate that the ARC algorithm generally produces highly intelligible speech. However, the scores under the optimal conditions indicate that this speech coder is rather speaker sensitive; the DRT scores range from 94.1 to 87.4. The DAM scores of the ARC speech coder are shown in Table LVI.

c. Codex ADM. The DRT scores of the Codex ADM speech coder are shown in Table LVII. These scores indicate that the speech produced by this coder is highly intelligible. The DRT scores under the optimal conditions indicate that this speech coder is speaker sensitive; the DRT scores range from 91.9 to 84.8. The speech quality test scores are presented in Table LVIII.

d. Schilling CVSD 16 kb/s. The DRT scores of the Schilling CVSD speech coder operating at 16 kb/s are shown in Table LIX. Additional intelligibility tests were performed with cutoff frequencies of 2.0 kHz and 2.5 kHz for the audio output filter. These scores indicate that this coder generally produces highly intelligible speech. The DAM scores of this speech coder are shown in Table LX.

e. Schilling CVSD 32 kb/s. The DRT scores of the Schilling CVSD speech coder operating at 32 kb/s are shown in Table LXI. These results indicate that the intelligibility of speech produced by this coder is quite high. The speech quality scores are shown in Table LXII.

f. Sylvania APCQ. Table LXIII lists the DRT scores of the Sylvania APCQ speech coder. The intelligibility scores are generally quite high. It can be seen that speech intelligibility is reduced significantly under conditions of 5% BER and five links in tandem. The quality scores are shown in Table LXIV. The DAM scores are generally consistent with the DRT scores.

g. LOG CVSD. Tables LXV, LXVI, and LXVII list the DRT scores of LOG CVSD operating at 16 kb/s, LOG CVSD operating at 32 kb/s, and General Dynamics CVSD respectively. The DRT scores under optimal conditions are 10 to 15 points lower then expected. This appears to be the result of improper tape recording levels or malfunctioning recording equipment. Tables LXVIII, LXIX, and LXX list the DAM results of LOG CVSD operating at 16 kb/s, LOG CVSD operating at 32 kb/s, and General Dynamics CVSD respectively. The quality test scores appear to be valid and should give a reliable estimate of user acceptance of these speech coders.

IV. CONCLUSIONS

Generally, under optimal conditions, all coders produced speech of high intelligibility. The performance of the CVSD coder operating at 32 kb/s was superior to the performance of the other coders operating at 16 kb/s. Overall, the performance of the Codex CVSD coder was superior to that of the other CVSD speech coders operating at 16 kb/s. Under nontactical conditions the performance of the Sylvania APCQ speech coder was superior to the CVSD operating at 32 kb/s on some tests. Under tactical conditions the performance of the Codex CVSD coder was superior to that of the other 16 kb/s speech coders.

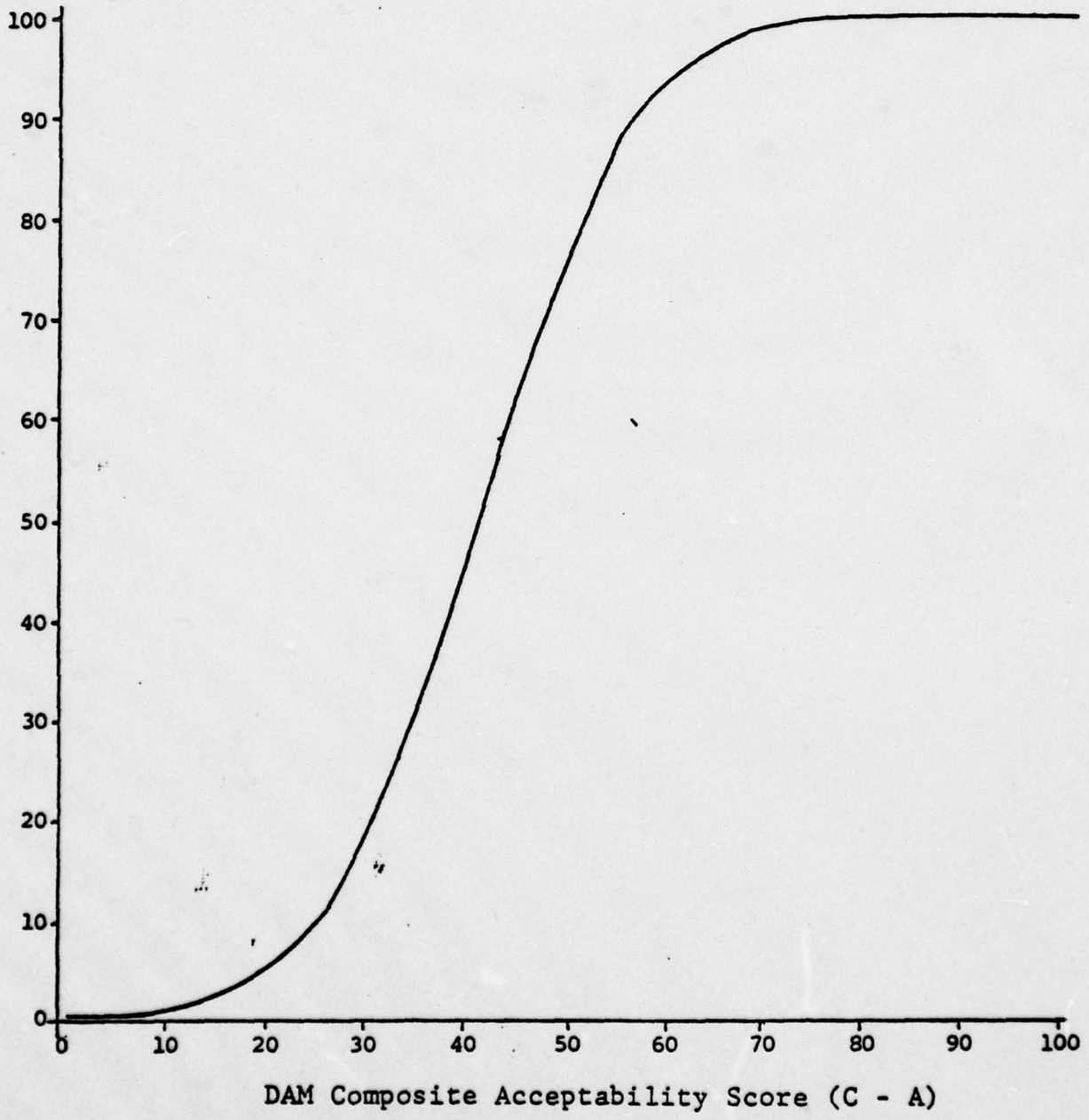

FIGURE 1. NOMOGRAPH TO CONVERT FROM COMPOSITE ACCEPTABILITY SCORE TO PERCENT USER ACCEPTANCE

TABLE I. MATRIX OF CODERS VS TESTS PERFORMED

	OPTIMAL COND.	OFFICE NOISE	ABCP NOISE	HELI NOISE	.1% BER	1% BER	+ 6 dB INPUT	- 12 dB INPUT	- 20 dB INPUT	TANDEM 2X - 0% BER	TANDEM 3X - 0% BER	TANDEM 5X - 0% BER	TANDEM LPC INTO W	TANDEM W INTO LPC
CVSD B COD 16	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT	DRT DAM	DRT DAM	DRT DAM
COD ARC 16	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM
COD ADM 16	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM
SCHIL 16/3	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM
SCHIL 32/4	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM
SYLM APCQ 16	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM
LOG CVSD 16	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	DRT DAM	

TABLE II. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: QUIET BER: 0% INPUT: 0dB SPEAKERS: 6 MALE

SCORES	S.E.	SYSTEM NAME	NO.	4	0	5	1	3	2	6
94.8	.50	SCHIL 32/4	4		1.4	2.5	3.0	4.2	5.6	21.7
93.4	.40	CVSD B COD 16	0	.95		1.1	1.6	2.8	4.2	20.3
92.3	.20	SYLM APCQ 16	5	.99			0.5	1.7	3.1	19.2
91.8	.60	COD ARC 16	1	.99	.99			1.2	2.6	18.7
90.6	.50	SCHIL 16/3	3	.99	.99	.99	.90		1.4	17.5
89.2	.50	COD ADM 16	2	.99	.99	.99	.99	.95		16.1
73.1	.60	LOG CVSD 16	6	.99	.99	.99	.99	.99	.99	

AVERAGE STANDARD ERROR = .488
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE III. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: QUIET BER: 0% INPUT: 0dB SPEAKERS: 2 MALE

SCORES	S.E.	SYSTEM NAME	NO.	4	5	1	6	0	3	2
61.1	1.20	SCHIL 32/4	4		4.1	7.0	10.6	10.6	11.1	11.2
57.0	1.60	SYLM APCQ 16	5	.95		2.9	6.5	6.5	7.0	7.1
54.1	1.20	COD ARC 16	1	.99	.90		3.6	3.6	4.1	4.2
50.5	1.10	LOG CVSD 16	6	.99	.99	.90		0.0	0.5	0.6
50.5	0.10	CVSD B COD 16	0	.99	.99	.90			0.5	0.6
50.0	1.30	SCHIL 16/3	3	.99	.99	.90				0.1
49.9	0.50	COD ADM 16	2	.99	.99	.90				

AVERAGE STANDARD ERROR = 1.108
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE IV.. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: QUIET BER: 0% INPUT: 0dB SPEAKERS 3 FEMALE

SCORES	S.E.	SYSTEM NAME	NO.	4	0	5	1	2	3	6
95.6	.70	SCHIL 32/4	4		3.7	4.3	5.8	7.9	8.1	20.8
91.9	.70	CVSD B COD 16	0	.99		0.6	2.1	4.2	4.4	17.1
91.3	.70	SYLM APCQ 16	5	.99			1.5	3.6	3.8	16.5
89.8	.50	COD ARC 16	1	.99	.90			2.1	2.3	15.0
87.7	.50	COD ADM 16	2	.99	.99	.99	.90		0.2	12.9
87.5	.90	SCHIL 16/3	3	.99	.99	.99	.90			12.7
74.8	.80	LOG CVSD 16	6	.99	.99	.99	.99	.99	.99	

AVERAGE STANDARD ERROR = .699
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE V. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: QUIET BER: 0% INPUT: 0dB SPEAKERS: 1 FEMALE

SCORES	S.E.	SYSTEM NAME	NO.	4	5	1	0	3	6	2
61.5	2.30	SCHIL 32/4	4		1.2	9.7	9.9	12.0	12.9	13.6
60.3	2.30	SYLM APCQ 16	5			8.5	8.7	10.8	11.7	12.4
51.8	1.70	COD ARC 16	1	.99	.99		0.2	2.3	3.2	3.9
51.6	1.10	CVSD B COD 16	0	.99	.99			2.1	3.0	3.7
49.5	1.30	SCHIL 16/3	3	.99	.99				0.9	1.6
48.6	1.30	LOG CVSD 16	6	.99	.99					0.7
47.9	1.50	COD ADM 16	2	.99	.99					

AVERAGE STANDARD ERROR = 1.703
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE VI. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: OFFICE BER: 0% INPUT: 0% SPEAKERS: 1 MALE

SCORES	S.E.	SYSTEM NAME	NO.	4	5	1	0	3	2	6
94.5	.50	SCHIL 32/4	4		0.4	0.4	0.8	3.1	3.1	6.6
94.1	.50	SYLM APCQ 16	5			0.0	0.4	2.7	2.7	6.2
94.1	.50	COD ARC 16	1				0.4	2.7	2.7	6.2
93.7	.60	CVSD B COD 16	0					2.3	2.3	5.8
91.4	.90	SCHIL 16/3	3	.90	.90	.90	.90		0.0	3.5
91.4	.90	COD ADM 16	2	.90	.90	.90	.90			3.5
87.9	1.10	LOG CVSD 16	6	.99	.99	.99	.99	.99	.99	

AVERAGE STANDARD ERROR = .750
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE VII. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: OFFICE BER: 0% INPUT: 0dB SPEAKERS: 3 MALE

SCORES	S.E.	SYSTEM NAME	NO.	4	1	5	3	6	0	2
63.3	.80	SCHIL 32/4	4		4.6	6.2	7.0	7.1	7.1	8.7
58.7	.70	COD ARC 16	1	.99		1.6	2.4	2.5	2.5	4.1
57.1	1.30	SYLM APCQ 16	5	.99			0.8	0.9	0.9	2.5
56.3	.60	SCHIL 16/3	3	.99				0.1	0.1	1.7
56.2	1.40	LOG CVSD 16	6	.99					0.0	1.6
56.2	.80	CVSD B COD 16	0	.99						1.6
54.6	.70	COD ADM 16	2	.99	.95					

AVERAGE STANDARD ERROR = .946
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE VIII. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: OFFICE BER: 0% INPUT: 0dB SPEAKERS: 1 FEMALE

SCORES	S.E.	SYSTEM NAME	NO.	2	4	5	0	1	3	6
89.8	.80	COD ADM 16	2		0.1	4.4	5.0	6.3	7.8	8.7
89.7	.30	SCHIL 32/4	4			4.3	4.9	6.2	7.7	8.6
85.4	.90	SYLM APCQ 16	5	.99	.99		0.6	1.9	3.4	4.3
84.8	1.30	CVSD B COD 16	0	.99	.99			1.3	2.8	3.7
83.5	1.20	COD ARC 16	1	.99	.99				1.5	2.4
82.0	.90	SCHIL 16/3	3	.99	.99	.90				0.9
81.1	1.30	LOG CVSD 16	6	.99	.99	.95	.90			

AVERAGE STANDARD ERROR = 1.012
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE IX. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: OFFICE BER: 0% INPUT: 0dB SPEAKERS: 1 FEMALE

SCORES	S.E.	SYSTEM NAME	NO.	4	0	1	3	5	6	2
67.4	1.50	SCHIL 32/4	4		5.0	7.2	8.6	9.8	13.9	15.7
62.4	1.80	CVSD B COD 16	0	.95		2.2	3.6	4.8	8.9	10.7
60.2	1.50	COD ARC 16	1	.99			1.4	2.6	6.7	8.5
58.8	1.20	SCHIL 16/3	3	.99				1.2	5.3	7.1
57.6	2.50	SYLM APCQ 16	5	.99					4.1	5.9
53.5	1.30	LOG CVSD 16	5	.99	.99	.95	.90	.90		1.8
51.7	1.30	COD ADM 16	2	.99	.99	.99	.95	.95		

AVERAGE STANDARD ERROR = 1.639
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE X. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: ABCP BER: 0% INPUT: 0dB SPEAKERS: 2 MALE

SCORES	S.E.	SYSTEM NAME	NO.	4	0	1	3	5	2	6
93.3	.60	SCHIL 32/4	4		4.0	5.1	5.8	7.2	10.6	11.4
89.8	.80	CVSD B COD 16	0	.99		1.1	1.8	3.2	6.6	7.4
88.7	.70	COD ARC 16	1	.99			.7	2.1	5.5	6.3
88.0	1.10	SCHIL 16/3	3	.99				1.4	4.8	5.6
86.6	.60	SYLM APCQ 16	5	.99	.95				3.4	4.2
83.2	.70	COD ADM 16	2	.99	.99	.99	.99	.99		0.8
82.4	.60	LOG CVSD 16	6	.99	.99	.99	.99	.99		

AVERAGE STANDARD ERROR = .747
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XI. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: ABCP BER: 0% INPUT: 0dB SPEAKERS: 3 MALE

SCORES	S.E.	SYSTEM NAME	NO.	4	0	1	5	3	6	2
61.3	1.10	SCHIL 32/4	4		7.3	8.7	9.8	10.8	10.9	11.5
54.0	.70	CVSD B COD 16	0	.99		1.4	2.5	3.5	3.6	4.2
52.6	.90	COD ARC 16	1	.99			1.1	2.1	2.2	2.8
51.5	1.30	SYLM APCQ 16	5	.99				1.0	1.1	1.7
50.5	1.40	SCHIL 16/3	3	.99					0.1	0.7
50.4	1.30	LOG CVSD 16	6	.99						0.6
49.8	.90	COD ADM 16	2	.99	.90					

AVERAGE STANDARD ERROR = 1.112
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XII. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: HELI BER: 0% INPUT: 0dB SPEAKERS: 2 MALE

SCORES	S.E.	SYSTEM NAME	NO.	4	6	5	0	1	2	3
74.6	1.20	SCHIL 32/4	4		2.4	2.9	3.8	3.9	4.4	4.7
72.2	1.20	LOG CVSD 16	6			0.5	1.4	1.5	2.0	2.3
71.7	1.30	SYLM APCQ 16	5				0.9	1.0	1.5	1.8
70.8	1.30	CVSD B COD 16	0					0.1	0.6	0.9
70.7	1.40	COD ARC 16	1						0.5	0.8
70.2	1.00	COD ADM 16	2							0.3
69.9	1.50	SCHIL 16/3	3							

AVERAGE STANDARD ERROR = 1.280
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XIII. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: HELI BER: 0% INPUT: 0dB SPEAKERS: 3 MALE

SCORES	S.E.	SYSTEM NAME	NO.	5	4	2	3	1	6	0
42.7	1.10	SYLM APCQ 16	5		0.9	1.6	1.9	2.0	3.1	10.9
41.8	1.00	SCHIL 32/4	4			0.7	1.0	1.1	2.2	10.0
41.1	.80	COD ADM 16	2				0.3	0.4	1.5	9.3
40.8	1.00	SCHIL 16/3	3					0.1	1.2	9.0
40.7	1.00	COD ARC 16	1						1.1	8.9
39.6	1.00	LOG CVSD 16	6							7.8
31.8	1.50	CVSD B COD 16	0	.99	.99	.99	.99	.99	.99	

AVERAGE STANDARD ERROR = 1.076
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XIV. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: QUIET BER: .1% INPUT: 0dB SPEAKERS: 2 MALE

SYSTEM

SCORES	S.E.	NAME	NO.	4	0	1	5	2	3	6
94.7	1.00	SCHIL 32/4	4		1.0	2.0	2.3	2.8	3.9	10.5
93.7	.50	CVSD B COD 16	0			1.0	1.3	1.8	2.9	9.5
92.7	.80	COD ARC 16	1				0.3	0.8	1.9	8.8
92.4	.80	SYLM APCQ 16	5					0.5	1.6	8.2
91.9	.50	COD ADM 16	2	.90					1.1	7.7
90.8	.30	SCHIL 16/3	3	.99	.90					6.6
84.2	.90	LOG CVSD 16	6	.99	.99	.99	.99	.99	.99	

AVERAGE STANDARD ERROR = .725
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XV. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: QUIET BER: .1% INPUT: 0dB SPEAKERS: 2 MALE

SCORES	S.E.	SYSTEM NAME	NO.	4	5	1	3	0	2	6
61.4	.90	SCHIL 32/4	4		4.4	8.2	9.3	9.6	11.7	14.7
57.0	1.80	SYLM APCQ 16	5	.99		3.8	4.9	5.2	7.3	10.3
53.2	1.20	COD ARC 16	1	.99	.95		1.1	1.4	3.5	6.5
52.1	.70	SCHIL 16/3	3	.99	.95			0.3	2.4	5.4
51.8	1.20	CVSD B COD 16	0	.99	.95				2.1	5.1
49.7	.90	COD ADM 16	2	.99	.99					3.0
46.7	1.10	LOG CVSD 16	6	.99	.99	.99	.99	.99	.90	

AVERAGE STANDARD ERROR = 1.161
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XVI. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: QUIET BER: .1% INPUT 0dB SPEAKERS 1 FEMALE

SYSTEM SCORES	S.E.	NAME	NO.	4	0	5	3	1	2	6
95.7	.70	SCHIL 32.4	4		2.5	3.8	4.3	5.2	7.2	17.7
93.2	.90	CVSD B COD 16	0	.90		1.3	1.8	2.7	4.7	15.2
91.9	.70	SYLM APCQ 16	5	.95			.5	1.4	3.4	13.9
91.4	.70	SCHIL 16/3	3	.95				.9	2.9	13.4
90.5	1.20	COD ARC 16	1	.99					2.0	12.5
88.5	1.00	COD ADM 16	2	.99	.95	.90				10.5
78.0	1.40	LOG CVSD 16	6	.99	.99	.99	.99	.99	.99	

AVERAGE STANDARD ERROR = .977
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XVII. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: QUIET BER: .1% INPUT: 0dB SPEAKERS: 1 FEMALE

SCORES	S.E.	SYSTEM NAME	NO.	5	4	1	3	0	2	6
60.5	2.80	SYLM APCQ 16	5		2.0	5.2	7.2	9.1	11.3	18.4
58.5	1.20	SCHIL 32/4	4			3.2	5.2	7.1	9.3	16.4
55.3	.80	COD ARC 16	1	.95			2.0	3.9	6.1	13.2
53.3	1.40	SCHIL 16/3	3	.99	.95			1.9	4.1	11.2
51.4	.90	CVSD B COD 16	0	.99	.99				2.2	9.3
49.2	1.00	COD ADM 16	2	.99	.99	.99				7.1
42.1	1.20	LOG CVSD 16	6	.99	.99	.99	.99	.99	.99	

AVERAGE STANDARD ERROR = 1.470
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XVIII. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: QUIET BER: 1% INPUT: 0dB SPEAKERS: 2 MALE

SCORES	S.E.	SYSTEM NAME	NO.	0	4	2	3	5	1	6
93.1	.50	CVSD B COD 16	0		1.3	3.8	4.3	5.3	6.4	14.8
91.8	.80	SCHIL 32/4	4			2.5	3.0	4.0	5.1	13.5
89.3	.40	COD ADM 16	2	.99	.95		.5	1.5	2.6	11.0
88.8	.00	SCHIL 16/3	3	.99	.95			1.0	2.1	10.5
87.8	.80	SYLM APCQ 16	5	.99	.99				1.1	9.5
86.7	1.10	COD ARC 16	1	.99	.99	.90				8.4
78.3	1.00	LOG CVSD 16	6	.99	.99	.99	.99	.99	.99	

AVERAGE STANDARD ERROR = .780
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XIX. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: QUIET BER: 1% INPUT: 0dB SPEAKERS: 2 MALE

SCORES	S.E.	SYSTEM NAME	NO.	4	2	6	1	3	5
50.7	.90	SCHIL 32/4	4		5.4	9.3	9.7	10.7	10.8
45.3	.50	COD ADM 16	2	.99		3.9	4.3	5.3	5.4
41.4	.00	LOG CVSD 16	6	.99	.99		0.4	1.4	1.5
41.0	1.50	COD ARC 16	1	.99	.99			1.0	1.1
40.0	1.00	SCHIL 16/3	3	.99	.99				0.1
39.9	1.20	SYLM APCQ 16	5	.99	.99				

AVERAGE STANDARD ERROR = .979
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XX. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: QUIET BER: 1% INPUT: 0dB SPEAKERS: 1 FEMALE

SCORES	S.E.	SYSTEM NAME	NO.	4	3	5	2	1	6
91.5	1.00	SCHIL 32/4	4		1.9	4.3	5.7	8.4	26.3
89.6	.90	SCHIL 16/3	3			2.4	3.8	6.5	24.4
87.2	.80	SYLM APCQ 16	5	.99	.90		1.4	4.1	22.0
85.8	.80	COD ADM 16	2	.99	.95			2.7	20.6
83.1	1.10	COD ARC 16	1	.99	.99	.99	.95		17.9
65.2	.90	LOG CVSD 16	6	.99	.99	.99	.99	.99	

AVERAGE STANDARD ERROR = .923
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XXI. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: QUIET BER: 1% INPUT: 0dB SPEAKERS: 1 FEMALE

SCORES	S.E.	SYSTEM NAME	NO.	2	4	6	5	3	1
45.0	1.80	COD ADM 16	2		0.2	4.4	4.4	6.0	6.1
44.8	1.80	SCHIL 32/4	4			4.2	4.2	5.8	5.9
40.6	1.50	LOG CVSD 16	6				0.0	1.6	1.7
40.6	1.30	SYLM APCQ 16	5					1.6	1.7
39.0	2.20	SCHIL 16/3	3						0.1
38.9	1.50	COD ARC 16	1						

AVERAGE STANDARD ERROR = 1.708
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XXII. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: QUIET BER: 0% INPUT 6dB SPEAKERS: 1 MALE

SYSTEM SCORES	S.E.	NAME	NO.	4	5	1	6	0	3
96.9	.50	SCHIL 32/4	4		.5	2.2	2.4	2.5	5.6
96.4	.40	SYLM APCQ 16	5			1.7	1.9	2.0	5,1
94.7	.90	COD ARC 16	1				.2	.3	3.4
94.5	.90	LOG CVSD 16	6					.1	3.2
94.4	.80	CVSD B COD 16	0						3.1
91.3	1.10	SCHIL 16/3	3	.99	.99	.95	.95	.95	

AVERAGE STANDARD ERROR = .804
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XXIII. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH NOISE: QUIET BER: 0% INPUT: 6dB SPEAKERS: 2 MALE

SCORES	S.E.	SYSTEM NAME	NO.	4	5	1	3	0	2	6
60.8	1.00	SCHIL 32/4	4		1.6	6.0	6.4	7.7	8.2	11.6
59.2	1.90	SYLM APCQ 16	5			4.4	4.8	6.1	6.6	10.0
54.8	.90	COD ARC 16	1	.99	.99		.4	1.7	2.2	5.6
54.4	1.00	SCHIL 16/3	3	.99	.99			1.3	1.8	5.2
53.1	.70	CVSD B COD 16	0	.99	.99				.5	3.9
52.6	.60	COD ADM 16	2	.99	.99					3.4
49.2	1.00	LOG CVSD 16	6	.99	.99	.99	.99	.95	.95	

AVERAGE STANDARD ERROR = 1.087
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XXIV. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: QUIET BER 0% INPUT: 6dB SPEAKERS: 1 FEMALE

SCORES	S.E.	SYSTEM NAME	NO.	4	5	1	3	0	2	6
62.8	1.80	SCHIL 32/4	4		3.1	7.7	9.4	10.2	10.4	12.6
59.7	3.00	SYLM APCQ 16	5			4.6	6.3	7.1	7.3	9.5
55.1	1.60	COD ARC 16	1	.95	.90		1.7	2.5	2.7	4.9
53.4	.90	SCHIL 16/3	3	.99	.90			.8	1.0	3.2
52.6	1.30	CVSD B COD 16	0	.99	.90				.2	2.4
52.4	2.30	COD ADM 16	2	.99	.90					2.2
50.2	1.20	LOG CVSD 16	6	.99	.99					

AVERAGE STANDARD ERROR = 1.853
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XXV. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: QUIET BER: 0% INPUT: -12dB SPEAKERS: 1 MALE

SYSTEM SCORES	S.E.	NAME	NO.	4	5	0	3	1	6	2
95.1	.60	SCHIL 32/4	4		2.5	3.3	6.3	7.2	10.6	15.9
92.6	1.10	SYLM APCQ 16	5	.90		.8	3.8	4.7	8.1	13.4
91.8	.80	CVSD B COD 16	0	.90			3.0	3.9	7.3	12.6
88.8	.70	SCHIL 16/3	3	.99	.95	.95		.9	4.3	9.6
87.9	1.10	COD ARC 16	1	.99	.99	.95			3.4	8.7
84.5	1.20	LOG CVSD 16	6	.99	.99	.99	.99	.95		5.3
79.2	1.20	COD ADM 16	2	.99	.99	.99	.99	.99	.99	

AVERAGE STANDARD ERROR = .985
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XXVI. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: QUIET BER: 0% INPUT: -12dB SPEAKERS: 2 MALE

SCORES	S.E.	SYSTEM NAME	NO.	5	0	4	3	1	6	2
55.6	1.60	SYLM APCQ 16	5		2.1	3.4	8.0	8.1	12.1	13.1
53.5	.90	CVSD B COD 16	0			1.3	5.9	6.0	10.0	11.0
52.2	.80	SCHIL 32/4	4	.90			4.6	4.7	8.7	9.7
47.6	.90	SCHIL 16/3	3	.99	.99	.95		.1	4.1	5.1
47.5	.80	COD ARC 16	1	.99	.99	.95			4.0	5.0
43.5	1.30	LOG CVSD 16	6	.99	.99	.99	.95	.95		1.0
42.5	1.20	COD ADM 16	2	.99	.99	.99	.99	.99		

AVERAGE STANDARD ERROR = 1.108
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XXVII. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: QUIET BER: 0% INPUT: -12dB SPEAKERS: 1 FEMALE

SCORES	S.E.	SYSTEM NAME	NO.	5	0	4	1	3	6	2
54.9	2.00	SYLM APCQ 16	5		4.0	4.3	7.6	10.9	12.0	12.9
50.9	1.20	CVSD B COD 16	0	.90		.3	3.6	6.9	8.0	8.9
50.6	1.80	SCHIL 32/4	4	.90			3.3	6.6	7.7	8.6
47.3	1.60	COD ARC 16	1	.99				3.3	4.4	5.3
44.0	.90	SCHIL 16/3	3	.99	.99	.99	.90		1.1	2.0
42.9	.80	LOG CVSD 16	6	.99	.99	.99	.90			.9
42.0	.90	COD ADM 16	2	.99	.99	.99	.95			

AVERAGE STANDARD ERROR = 1.389
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XXVIII. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: QUIET BER 0% INPUT: -20dB SPEAKERS: 1 MALE

SCORES	S.E.	SYSTEM NAME	NO.	4	0	5	3	1	2	6
91.8	1.30	SCHIL 32/4	4		4.7	5.3	7.2	13.5	15.2	17.2
87.1	1.30	CVSD B COD 16	0	.95		.6	2.5	8.8	10.5	12.5
86.5	1.60	SYLM APCQ 16	5	.95			1.9	8.2	9.9	11.9
84.6	1.30	SCHIL 16/3	3	.99				6.3	8.0	10.0
78.3	.90	COD ARC 16	1	.99	.99	.99	.99		1.7	3.7
76.6	1.40	COD ADM 16	2	.99	.99	.99	.99			2.0
74.6	1.00	LOG CVSD 16	6	.99	.99	.99	.99			

AVERAGE STANDARD ERROR = 1.276
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XXIX. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: QUIET BER: 0% INPUT: -20dB SPEAKERS: 2 MALE

SCORES	S.E.	SYSTEM NAME	NO.	5	0	4	3	1	2	6
53.2	.70	SYLM APCQ 16	5		7.8	9.0	11.3	11.4	14.0	14.9
45.4	.90	CVSD B COD 16	0	.99		1.2	3.5	3.6	6.2	7.1
44.2	1.10	SCHIL 32/4	4	.99			2.3	2.4	5.0	5.9
41.9	1.00	SCHIL 16/3	3	.99	.90			.1	2.7	3.6
41.8	1.10	COD ARC 16	1	.99	.90				2.6	3.5
39.2	1.10	COD ADM 16	2	.99	.99	.99	.90			.9
38.3	1.30	LOG CVSD 16	6	.99	.99	.99	.90	.90		

AVERAGE STANDARD ERROR = 1.043
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XXX. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: QUIET BER: 0% INPUT: -20dB SPEAKERS: 1 FEMALE

SCORES	S.E.	SYSTEM NAME	NO.	5	0	1	3	4	2	6
51.1	2.00	SYLM APCQ 16	5		6.5	7.2	8.6	10.7	13.8	14.2
44.6	.90	CVSD B COD 16	0	.99		.7	2.1	4.2	7.3	7.7
43.9	1.40	COD ARC 16	1	.99			1.4	3.5	6.6	7.0
42.5	1.00	SCHIL 16/3	3	.99				2.1	5.2	5.6
40.4	.70	SCHIL 32/4	4	.99	.90				3.1	3.5
37.3	1.30	COD ADM 16	2	.99	.99	.99	.95			.4
36.9	.90	LOG CVSD 16	6	.99	.99	.99	.95			

AVERAGE STANDARD ERROR = 1.240
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XXXI. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: TANDEM 2X BER: 0% INPUT: 0dB SPEAKERS: 1 MALE

SCORES	S.E.	SYSTEM NAME	NO.	1	6	5	2	0
93.1	1.20	COD ARC 16	1		2.2	2.3	2.3	2.7
90.9	.70	LOG CVSD 16	6			.1	.1	.5
90.8	1.20	SYLM APCQ 16	5					.4
90.8	.70	COD ADM 16	2					.4
90.4	.70	CVSD B COD 16	0					

AVERAGE STANDARD ERROR = .933
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XXXII. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: TANDEM 2X BER: 0% INPUT 0dB SPEAKERS: 2 MALE

SCORES	S.E.	SYSTEM NAME	NO.	4	1	0	3	2	5	6
58.7	1.10	SCHIL 32/4	4		6.9	7.8	8.9	9.5	12.4	14.6
51.8	.90	COD ARC 16	1	.99		.9	2.0	2.6	5.5	7.7
50.9	1.20	CVSD B COD 16	0	.99			1.1	1.7	4.6	6.8
49.8	.70	SCHIL 16.3	3	.99				.6	3.5	5.7
49.2	.80	COD ADM 16	2	.99					2.9	5.1
46.3	1.00	SYLM APCQ 16	5	.99	.99	.99	.95	.95		2.2
44.1	1.10	LOG CVSD 16	6	.99	.99	.99	.99	.99		

AVERAGE STANDARD ERROR = .986
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XXXIII. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: TANDEM 2X | BER: 0% INPUT: 0dB SPEAKERS: 1 FEMALE

SYSTEM SCORES	S.E.	NAME	NO.	1	2	0
88.7	1.00	COD ARC 16	1		3.5	4.1
85.2	1.10	COD ADM 16	2	.95		.6
84.6	1.20	CVSD B COD 16	0	.95		

AVERAGE STANDARD ERROR = 1.103
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XXXIV. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: TANDEM 2X BER: 0% INPUT: 0dB SPEAKERS: 1 FEMALE

SCORES	S.E.	SYSTEM NAME	NO.	4	1	0	5	3	2	6
56.7	2.10	SCHIL 32/4	4		4.5	5.0	5.8	5.9	10.0	12.6
52.2	1.20	COD ARC 16	1	.95		0.5	1.3	1.4	5.5	8.1
51.7	1.50	CVSD B COD 16	0	.95			0.8	0.9	5.0	7.6
50.9	1.70	SYLM APCQ 16	5	.95				0.1	4.2	6.8
50.8	1.20	SCHIL 16/3	3	.95					4.1	6.7
46.7	1.20	COD ADM 16	2	.99	.90	.90				2.6
44.1	.70	LOG CVSD 16	6	.99	.99	.99	.99	.99		

AVERAGE STANDARD ERROR = 1.432
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XXXV. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: TANDEM 3X BER: 0dB INPUT: 0dB SPEAKERS: 1 MALE

SCORES	S.E.	SYSTEM NAME	NO.	4	0	1	3	2	6	5
94.4	1.90	SCHIL 32/4	4		2.6	3.8	8.7	9.2	11.7	15.2
91.8	1.20	CVSD B COD 16	0			1.2	6.1	6.6	9.1	12.6
90.6	1.00	COD ARC 16	1	.90			4.9	5.4	7.9	11.4
85.7	1.00	SCHIL 16/3	3	.99	.99	.99		0.5	3.0	6.5
85.2	.60	COD ADM 16	2	.99	.99	.99			2.5	6.0
82.7	.60	LOG CVSD 16	6	.99	.99	.99				3.5
79.2	1.20	SYLM APCQ 16	5	.99	.99	.99	.99	.99	.95	

AVERAGE STANDARD ERROR = 1.147
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XXXVI. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: TANDEM 3X BER: 0% INPUT: 0dB SPEAKERS: 2 MALE

SCORES	S.E.	SYSTEM NAME	NO.	4	1	3	2	6	5
56.8	.90	SCHIL 32/4	4		4.1	8.5	11.1	12.2	17.8
52.7	.90	COD ARC 16	1	.95		4.4	7.0	8.1	13.7
48.3	1.20	SCHIL 16/3	3	.99	.95		2.6	3.7	9.3
45.7	1.10	COD ADM 16	2	.99	.99			1.1	6.7
44.6	1.20	LOG CVSD 16	6	.99	.99				5.6
39.0	2.10	SYLM APCQ 16	5	.99	.99	.99	.99	.99	

AVERAGE STANDARD ERROR = 1.299
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XXXVII. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: TANDEM 3X BER: 0% INPUT: 0dB SPEAKERS: 1 FEMALE

SCORES	S.E.	SYSTEM NAME	NO.	4	3	1	2	6	5
57.4	1.70	SCHIL 32/4	4		9.6	9.9	13.6	14.7	16.2
47.8	1.40	SCHIL 16/3	3	.99		0.3	4.0	5.1	6.6
47.5	1.10	COD ARC 16	1	.99			3.7	4.8	6.3
43.8	2.00	COD ADM 16	2	.99				1.1	2.6
42.7	1.00	LOG CVSD 16	6	.99	.90	.90			1.5
41.2	1.30	SYLM APCQ 16	5	.99	.95	.95			

AVERAGE STANDARD ERROR = 1.458
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XXXVIII. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: TANDEM 5X BER: 0% INPUT: 0dB SPEAKERS: 1 MALE

SCORES	S.E.	SYSTEM NAME	NO.	4	0	1	2	3	6	5
93.1	1.10	SCHIL 32/4	4		3.9	7.0	13.3	14.6	18.4	30.7
89.2	.90	CVSD B COD 16	0	.95		3.1	9.4	10.7	14.5	26.8
86.1	1.10	COD ARC 16	1	.99	.90		6.3	7.6	11.4	23.7
79.8	.80	COD ADM 16	2	.99	.99	.99		1.3	5.1	17.4
78.5	1.60	SCHIL 16/3	3	.99	.99	.99			3.8	16.1
74.7	1.40	LOG CVSD 16	6	.99	.99	.99	.95	.95		12.3
62.4	1.50	SYLM APCQ 16	5	.99	.99	.99	.99	.99	.99	

AVERAGE STANDARD ERROR = 1.233
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XXXIX. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: TANDEM 5X BER: 0% INPUT: 0dB SPEAKERS: 2 MALE

SCORES	S.E.	SYSTEM NAME	NO.	4	1	0	3	2	6	5
52.9	1.00	SCHIL 32/4	4		8.6	9.8	9.9	14.0	16.5	27.3
44.3	1.10	COD ARC 16	1	.99		1.2	1.3	5.4	7.9	18.7
43.1	1.10	CVSD B COD 16	0	.99			0.1	4.2	6.7	17.5
43.0	1.20	SCHIL 16/3	3	.99				4.1	6.6	17.4
28.9	1.30	COD ADM 16	2	.99	.95	.90	.90		2.5	13.3
36.4	1.30	LOG CVSD 16	6	.99	.99	.99	.99			10.8
25.6	2.10	SYLM APCQ 16	5	.99	.99	.99	.99	.99	.99	

AVERAGE STANDARD ERROR = 1.344
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XL. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: TANDEM 5X BER: 0% INPUT: 0dB SPEAKERS: 1 FEMALE

SCORES	S.E.	SYSTEM NAME	NO.	4	1	3	0	2	6	5
46.2	1.40	SCHIL 32/4	4		1.8	3.7	5.2	7.3	8.9	19.2
44.4	.90	COD ARC 16	1			1.9	3.4	5.5	7.1	17.4
42.5	1.30	SCHIL 16/3	3				1.5	3.6	5.2	15.5
41.0	1.10	CVSD B COD 16	0	.90				2.1	3.7	14.0
38.9	1.30	COD ADM 16	2	.99	.95				1.6	11.9
37.3	1.10	LOG CVSD 16	6	.99	.99	.90				10.3
27.0	2.30	SYLM APCQ 16	5	.99	.99	.99	.99	.99	.99	

AVERAGE STANDARD ERROR = 1.407
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XLI. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: LPC INTO W BER: 0% INPUT: 0dB SPEAKERS: 1 MALE

SCORES	S.E.	SYSTEM NAME	NO.	0	4	3	1	2	5	6
88.4	.50	CVSD B COD 16	0		2.1	2.4	2.6	2.7	3.4	11.4
86.3	1.00	SCHIL 32/4	4			0.3	0.5	0.6	1.3	9.3
86.0	1.10	SCHIL 16/3	3				0.2	0.3	1.0	9.0
85.8	1.20	COD ARC 16	1					0.1	0.8	8.8
85.7	1.10	COD ADM 16	2						0.7	8.7
85.0	1.00	SYLM APCQ 16	5							8.0
77.0	1.10	LOG CVSD 16	6	.99	.99	.99	.99	.99	.99	

AVERAGE STANDARD ERROR = 1.023
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XLII. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: LPC INTO W BER: 0% INPUT: 0dB SPEAKERS: 2 MALE

SCORES	S.E.	SYSTEM NAME	NO.	4	1	0	2	6	5	3
48.2	1.40	SCHIL 32/4	4		2.2	2.9	3.6	3.8	3.8	4.2
46.0	1.60	COD ARC 16	1			0.7	1.4	1.6	1.6	2.0
45.3	1.20	CVSD B COD 16	0				0.7	0.9	0.9	1.3
44.6	1.30	COD ADM 16	2					0.2	0.2	0.6
44.4	.90	LOG CVSD 16	6						0.0	0.4
44.4	1.80	SYLM APCQ 16	5							0.4
44.0	1.00	SCHIL 16/3	3							

AVERAGE STANDARD ERROR = 1.347
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XLIII. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: LPC INTO W BER: 0% INPUT: 0dB SPEAKERS: 1 FEMALE

SCORES	S.E.	SYSTEM NAME	NO.	2	1	4	0	3	5
82.4	.60	COD ADM 16	2		3.8	4.4	5.3	6.5	6.6
78.6	1.30	COD ARC 16	1	.90		0.6	1.5	2.7	2.8
78.0	1.30	SCHIL 32/4	4	.90			0.9	2.1	2.2
77.1	1.10	CVSD B COD 16	0	.95				1.2	1.3
75.9	2.10	SCHIL 16/3	3	.95					0.1
75.8	1.20	SYLM APCQ 16	5	.95					

AVERAGE STANDARD ERROR = 1.342
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XLIV. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: LPC INTO W BER: 0% INPUT: 0dB SPEAKERS: 1 FEMALE

SCORES	S.E.	SYSTEM NAME	NO.	4	1	5	2	0	6	3
44.0	2.20	SCHIL 32/4	4		1.6	2.6	3.9	4.0	4.4	4.7
42.4	1.80	COD ARC 16	1			1.0	2.3	2.4	2.8	3.1
41.4	1.50	SYLM APCQ 16	5				1.3	1.4	1.8	2.1
40.1	2.00	COD ADM 16	2					0.1	0.5	0.8
40.0	1.20	CVSD B COD 16	0						0.4	0.7
39.6	1.50	LOG CVSD 16	6							0.3
39.3	1.20	SCHIL 16/3	3							

AVERAGE STANDARD ERROR = 1.667
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XLV. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: W INTO LPC BER: 0% INPUT: 0dB SPEAKERS: 1 MALE

SCORES	S.E.	SYSTEM NAME	NO.	5	1	0	2	3	4
86.8	.80	SYLM APCQ 16	5		3.9	4.6	7.0	8.5	15.2
82.9	.80	COD ARC 16	1	.90		0.7	3.1	4.6	11.3
82.2	.80	CVSD B COD 16	0	.90			2.4	3.9	10.6
79.8	1.10	COD ADM 16	2	.95				1.5	8.2
78.3	1.40	SCHIL 16/3	3	.99					6.7
71.6	2.90	SCHIL 32/4	4	.99	.99	.99	.99	.99	

AVERAGE STANDARD ERROR = 1.500
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XLVI. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH NOISE: W INTO LPC BER: 0% INPUT: 0dB SPEAKERS: 2 MALE

SCORES	S.E.	SYSTEM NAME	NO.	4	5	1	3	2	0
47.1	1.60	SCHIL 32/4	4		2.0	2.6	3.9	4.3	6.3
45.1	1.30	SYLM APCQ 16	5			0.6	1.9	2.3	4.3
44.5	1.00	COD ARC 16	1				1.3	1.7	3.7
43.2	1.80	SCHIL 16/3	3					0.4	2.4
42.8	.80	COD ADM 16	2						2.0
40.8	1.20	CVSD B COD 16	0	.95					

AVERAGE STANDARD ERROR = 1.327
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XVII. NEUMAN-KUELS ANALYSIS OF SYSTEM DRT SCORES WITH
NOISE: W INTO LPC BER: 0% INPUT: 0dB SPEAKERS: 1 FEMALE

SCORES	S.E.	SYSTEM NAME	NO.	4	3	5	1	0	2
82.0	1.40	SCHIL 32/4	4		7.1	8.7	14.4	15.1	18.3
74.9	1.50	SCHIL 16/3	3	.99		1.6	7.3	8.0	11.2
73.3	1.30	SYLM APCQ 16	5	.99			5.7	6.4	9.6
67.6	1.80	COD ARC 16	1	.99	.99	.95		0.7	3.9
66.9	1.80	CVSD B COD 16	0	.99	.99	.95			3.2
63.7	1.70	COD ADM 16	2	.99	.99	.99			

AVERAGE STANDARD ERROR = 1.595
NO. LISTENERS = 8

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XLVIII. NEUMAN-KUELS ANALYSIS OF SYSTEM DAM SCORES WITH
NOISE: W INTO LPC BER: 0% INPUT: 0dB SPEAKERS: 1 FEMALE

SCORES	S.E.	SYSTEM NAME	NO.	5	4	1	2	3	0
43.7	1.60	SYLM APCQ 16	5		2.2	3.3	5.8	6.3	8.3
41.5	1.60	SCHIL 32/4	4			1.1	3.6	4.1	6.1
40.4	1.40	COD ARC 16	1				2.5	3.0	5.0
37.9	1.20	COD ADM 16	2	.95				0.5	2.5
37.4	1.10	SCHIL 16/3	3	.95					2.0
35.4	1.40	CVSD B COD 16	0	.99	.95	.90			

AVERAGE STANDARD ERROR = 1.396
NO. LISTENERS = 10

ABOVE DIAGONAL = SCORE DIFFERENCES
BELOW DIAGONAL = CONFIDENCE LEVELS

TABLE XLIX. RANKING OF 16 kb/s CODERS FOR MALE DRT

	OPTIMAL COND.	OFFICE NOISE	ABCP NOISE	HELI NOISE	.1% BER	1% BER	+ 6 dB INPUT	- 12 dB INPUT	- 20 dB INPUT	TANDEM 2X - 0 % BER	TANDEM 3X - 0 % BER	TANDEM 5X - 0 % BER	TANDEM LPC INTO W	TANDEM W INTO LPC
CVSD B COD 16	1	1	1	1	1	1	1	1	1	1	1	1	1	2
COD ARC 16	2	1	1	1	1	3	1	2	2	1	2	2	1	2
COD ADM 16	4	2	3	1	2	2	1	4	2	1	3	3	1	2
SCHIL 16/3	3	2	1	1	3	2	2	2	1		3	3	1	2
SCHIL 32/4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SYLM APCQ 16	1	1	2	1	1	2	1	1	1	1	4	5	1	1
LOG CVSD 16	5	3	3	1	4	4	1	3	2	1	3	4	2	

TABLE L. RANKING OF 16 kb/s CODERS FOR MALE DAM

	OPTIMAL COND.	OFFICE NOISE	ABCP NOISE	HELI NOISE	.1% BER	1% BER	+ 6 dB INPUT	- 12 dB INPUT	- 20 dB INPUT	TANDEM 2X - 0% BER	TANDEM 3X - 0% BER	TANDEM 5X - 0% BER	TANDEM LPC INTO W	TANDEM W INTO LPC
CVSD B COD 16	3	1	1	2	2	-	2	1	2	1	-	1	1	
COD ARC 16	2	1	1	1	2	2	2	3	3	1	1	1	1	
COD ADM 16	3	2	2	1	2	1	2	4	4	1	2	2	1	
SCHIL 16/3	3	1	1	1	2	2	2	3	3	1	2	1	1	
SCHIL 32/4	-	-	-	-	-	-	-	-	-	-	-	-	-	
SYLM APCQ 16	1	1	1	1	1	2	1	1	1	2	3	3	1	
LOG CVSD 16	3	1	1	1	3	2	3	4	5	2	2	2	1	

TABLE LI. RANKING OF 16 kb/s CODERS FOR FEMALE DRT

	OPTIMAL COND.	OFFICE NOISE	ABCP NOISE	HELI NOISE	.1% BER	1% BER	+ 6 dB INPUT	- 12 dB INPUT	- 20 dB INPUT	TANDEM 2X - 0% BER	TANDEM 3X - 0% BER	TANDEM 5X - 0% BER	TANDEM LPC INTO W	TANDEM W INTO LPC
CVSD B COD 16	1	2			1	-				2			2	2
COD ARC 16	2	2			1	2				1			2	2
COD ADM 16	3	1			2	2				2			1	2
SCHIL 16/3	3	3			1	1							2	1
SCHIL 32/4	-	-			-	1							-	-
SYLM APCQ 16	1	2			1	2							2	1
LOG CVSD 16	4	4			3	3								

TABLE LII. RANKING OF 16 kb/s CODERS FOR FEMALE DAM

	OPTIMAL COND	OFFICE NOISE	ABCP NOISE	HELI NOISE	.1% BER	1% BER	+ 6 dB INPUT	- 12 dB INPUT	- 20 dB INPUT	TANDEM 2X - 0% BER	TANDEM 3X - 0% BER	TANDEM 5X - 0% BER	TANDEM LPC INTO W	TANDEM W INTO LPC
CVSD B COD 16	2	1			3	1	2	2	2	1	-	2	1	3
COD ARC 16	2	1			2	1	2	2	2	1	1	1	1	1
COD ADM 16	2	2			4	1	2	3	4	2	1	3	1	2
SCHIL 16/3	2	1			3	1	2	3	2	1	1	1	1	2
SCHIL 32/4	-	-			-	-	-	-	-	-	-	-	-	-
SYLM APCQ 16	1	1			1	1	1	1	1	1	2	5	1	1
LOG CVSD 16	2	2			5	1	2	3	4	3	2	4	1	

TABLE LIII. DRT SCORES FOR CVSD B CODEX 16

TEST CONDITION	SPEAKER								
	LL	RH	CH	PK	JE	BV	JS	LS	MP
Optimum	93.0±.9 95.4±.9	95.2±.7	93.7±.9	91.5±.8	92.7±1.3	94.0±.9	91.9±1.3	92.2±.8	91.3±1.0
ERROR ENVIRONMENT									
.1% BER	91.9±.9	93.0±1.0						91.9±.7	
1% BER	93.0±.6	93.2±.6					90.5±1.3		
NOISE ENVIRONMENT									
Office		92.8±.9 93.7±.6	92.8±1.0		94.3±1.2		85.9±2.2 84.8±1.3		
ABCP		92.8±.5			86.7±1.8				
			89.5±1.0		86.8±1.0				
Helicopter		70.6±1.3 71.1±1.6			71.1±1.9 65.1±2.1				
DYNAMIC RANGE									
+6 dB		94.4±.8							
-12 dB		91.8±.8							
-20 dB		87.1±1.3							
TANDEM TESTS									
2X CVSD 0% BER	87.8±1.0	90.4±.7					84.6±1.2		
3X CVSD 0% BER	92.4±1.0	91.8±1.2							
5X CVSD 0% BER	89.1±.7	89.2±.9							
LPC — CVSD 0% BER	86.7±1.4	88.4±.5					77.1±1.1		
CVSD — LPC 0% BER	81.6±.8	82.1±.8					66.9±1.8		
OTHER TESTS									
5% BER	83.6±1.3	85.7±.9					80.2±1.5		
10% BER	78.8±.9	74.3±.1					73.0±1.0		
Tandem 3X .5%	88.9±.9								
5X .5%	84.4±.8								
7X .5%	76.2±1.5								
9X 0%	81.9±1.1								
13X 0%	77.1±.8								
ABCP Dyn Mic			78.9±1.2		78.6±1.5				

TABLE LIV. DAM SCORES FOR CVSD B CODEX 16

	SPEAKER					
TEST CONDITION	CH	LL	JE	RH	JS	MS
Optimum	60.5	56.9	63.3		53.6	52.8
	60.3	58.6	61.9			
BIT ERROR RATES						
.1% BER	52.4	51.3			51.4	
.5% BER	54.5	51.2			45.5	
1% BER	47.2	47.6	48.0		45.8	
1% BER	50.8	45.7	50.0			
1% BER	50.0	43.9			45.2	
5% BER	36.9	38.2	37.8			
5% BER	38.6	30.5			43.1	
10% BER	23.8	26.9	29.1			
10% BER	24.5	24.1				
NOISE BACKGROUND						
Office	55.9		57.8	55.1	62.4	
ABCP	52.9		54.5	54.6		
Helicopter	30.4		32.8	31.9		
DYNAMIC RANGE						
+6 dB	50.0	51.3			52.6	
-12 dB	54.5	52.5			50.9	
-20 dB	45.8	45.0			44.6	
TANDEMS						
2X 0 BER	51.3	50.6			51.7	
3X 0 BER	55.5	59.9			58.7	
5X 0 BER	47.5	44.9			39.1	
9X 0 BER	43.7	35.8			34.7	
13X 0 BER	35.5	37.0			29.0	
3X .5% BER	45.4	43.4			38.0	
5X .5% BER	39.0	38.4			34.2	
7X .5% BER	35.1	29.8			32.2	
LPC → CVSD	44.2	46.4			46.7	
CVSD → LPC	38.7	42.9			27.8	

TABLE LV. DRT SCORES OF CODEX ARC SPEECH CODER

TEST CONDITION	SPEAKER								
	LL	RH	CH	PK	JE	BV	JS	LS	MP
Optimum	93.6±.7	94.1±.7	93.5±1.1	92.3±.7	87.4±.8	89.6±1.1	89.6±1.0	90.4±1.0	89.5±.7
ERROR RATES									
.1% BER	92.2±.7	93.2±1.2					90.5±1.2		
1% BER	85.3±.9	88.0±1.7					83.1±1.1		
10% BER		19.1±2.2							
NOISE ENVIRONMENT									
OFFICE		94.1±.5					83.5±1.2		
ABCP		90.8±1.3			86.6±.6				
HELICOPTER		72.5±1.4			68.9±1.8				
DYNAMIC RANGE									
+6dB		94.7±.9							
-12dB		87.9±1.1							
-20dB		78.3±.9							
TANDEMS									
2X	92.4±.9	93.1±1.2					88.7±1.0		
3X		90.6±1.0							
5X		86.1±1.1							
LPC→W	83.7±1.5	85.8±1.2					78.6±1.3		
W→LPC	83.3±.7	82.9±.8					67.6±1.8		

TABLE LVI. DAM SCORES OF CODEX ARC SPEECH CODER

TEST CONDITION	SPEAKER CH	LL	JE	RH	JS
Optimum	55.4	52.7			51.8
ERROR RATES					
.1% BER	53.7	52.6			55.3
1% BER	42.4	39.5			38.9
NOISE BACKGROUND					
Office	58.1		58.9	59.2	60.2
ABCP	49.1		53.7	55.0	
Helicopter	40.6		41.7	39.5	
DYNAMIC RANGE					
+6 dB	56.3	53.2			55.1
-12 dB	46.6	48.5			47.3
-20 dB	40.8	42.7			43.9
TANDEMS					
2X	52.2	51.5			52.2
3X	55.2	50.3			47.5
5X	45.9	42.6			44.4
LPC —— W	45.1	46.9			42.4
W —— LPC	44.6	44.6			40.4

TABLE LVII. DRT SCORES OF CODEX ADM SPEECH CODER

TEST CONDITION	SPEAKER								
	LL	RH	CH	PK	JE	BV	JS	LS	MP
Optimum	91.9±.7	90.6±1.0	90.4±1.0	90.8±.9	84.8±.5	86.8±1.0	85.4±1.1	89.5±.5	88.2±1.2
ERROR RATE TESTS									
.1% BER	91.4±.7	92.4±.6					88.5±1.0		
1% BER	89.6±.5	89.5±.8					83.2±.7		
NOISE BACKGROUND									
Office		91.4±.9					89.8±.8		
ABCP		86.2±.8	84.5±.9		80.2±1.4				
Helicopter		70.8±1.7	72.3±1.5		69.5±1.5				
DYNAMIC RANGE									
+6dB	--- no data available								
-12dB	80.9±1.6	77.6±1.1					73.3±1.6		
-20dB		76.6±1.4							
TANDEM									
2X	91.1±.9	90.8±.7					85.2±1.1		
3X		85.2±.6							
5X		79.8±.8							
LPC→W	85.2±.9	85.7±1.1					82.9±.6		
W→LPC	82.3±1.1	79.8±1.1					63.7±1.7		

TABLE LVIII. DAM SCORES OF CODEX ADM SPEECH CODER

TEST CONDITION	SPEAKER				
	CH	LL	JE	RH	JS
Optimum	49.8	50.0			47.9
ERROR RATES					
.1% BER	49.7	49.8			49.2
1% BER	42.5	48.1			45.0
NOISE BACKGROUND					
Office	55.1		57.5	51.2	51.7
ABCP	47.1		52.2	50.1	
Helicopter	38.3		40.8	44.1	
DYNAMIC RANGE					
+6 dB	54.9	50.4			52.4
-12 dB	42.3	42.8			42.0
-20 dB	38.4	40.1			37.3
TANDEMS					
2X	49.0	49.4			46.7
3X	45.6	45.7			43.8
5X	39.5	38.4			38.9
LPC ——W	45.4	43.7			40.1
W ——LPC	42.9	47.6			37.9

TABLE LIX. DRT SCORES OF SCHILLING CVSD SPEECH CODER 16 kb/s

TEST CONDITION	SPEAKER								
	LL	RH	CH	PK	JE	BV	JS	LS	MP
*OPTIMUM	90.0±.8	90.4±1.1	92.7±1.2	91.3±1.1	88.7±1.3	90.6±1.2	87.9±1.3	85.9±1.2	88.8±1.5
ERROR RATE									
0.1% BER	90.1±.3	91.5±.5					91.4±.7		
1.0% BER	88.5±1.0	87.6±1.2					89.6±.9		
NOISE ENVIRONMENT									
OFFICE	91.4±.9						82.0±.9		
ABCP	91.4±.6				84.6±1.8				
HELICOPTER	69.7±1.5				70.2±2.3				
DYNAMIC RANGE									
+6dB	91.3±1.1								
-12dB	88.9±.7								
-20dB	84.6±1.3								
TANDEMS									
2X	88.9±.7								
3X	85.7±1.0								
4X	83.5±1.0								
5X	78.5±1.6								
LPC→ W	86.0±1.1						75.9±2.1		
W→LPC	78.3±1.4						74.9±1.5		
OTHER TESTS									
** SCHIL 16/2.5	90.8±.9	90.5±.6	92.1±.8	92.8±.8	86.7±.8	91.0±1.2	89.8±.7	90.1±.9	91.5±1.3
***SCHIL 16/2.0	90.8±.9	89.3±.7	92.3±1.1	91.7±.6	88.9±1.3	90.6±1.0	89.2±.8	88.8±1.5	91.1±1.5

*3.0 kHz output filter.
**2.5 kHz output filter.
***2. kHz output filter.

TABLE LX. DAM SCORES OF SCHILLING CVSD SPEECH CODER 16 kb/s

TEST CONDITION	CH	LL	JE	RH	JS
Optimum					
SCHIL 16/3	49.9	50.0			49.5
SCHIL 16/2.5	55.4	53.1			52.5
SCHIL 16/2.0	53.9	51.1			56.5
ERROR RATES					
.1% BER	52.5	51.6			53.3
1% BER	40.9	39.1			39.0
NOISE BACKGROUND					
Office	54.4		57.8	56.7	58.8
ABCP	50.3		51.0	50.0	
Helicopter	38.8		40.5	43.1	
DYNAMIC RANGE					
+6 dB	53.9	54.9			53.4
-12 dB	49.6	45.6			44.0
-20 dB	41.9	41.9			42.5
TANDEMS:					
2X	49.9	49.8			50.8
3X	48.9	47.6			57.8
5X	44.4	41.5			42.5
LPC —— W	43.9	44.1			39.3
W —— LPC	42.9	43.5			37.4

TABLE LXI. DRT SCORES OF SCHILLING CVSD SPEECH CODER 32 kb/s

TEST CONDITION	SPEAKER								
	LL	RH	CH	PK	JE	BV	JS	LS	MP
*OPTIMUM	93.9±.6	95.8±.5	96.9±.7	93.4±1.0	94.4±.6	94.7±1.0	94.7±.7	95.4±1.0	96.7±.9
ERROR RATES									
.1% BER	95.6±.8	94.9±1.4					95.7±.7		
1% BER	90.4±.9	93.2±1.0					91.5±1.0		
NOISE ENVIRONMENT									
OFFICE		94.5±.5					89.7±.3		
ABCP		97.3±.7			90.4±.5				
HELICOPTER		75.1±1.2			74.1±2.1				
DYNAMIC RANGE									
+6dB		96.9±.5							
-12dB		95.1±.6							
-20dB		91.8±1.3							
TANDEMS		96.7±.8							
2X	95.3±.8	96.4±.4	95.1±.7	94.8±.7	90.1±.3	93.5±.6	94.5±.5	94.5±.8	94.0±.8
3X		94.4±1.9							
4X		95.1±.7							
5X		93.1±1.1							
LPC→W		86.3±1.0					78.0±1.3		
W→LPC		85.9±2.1					82.0±1.4		
OTHER TESTS									
**SCHIL 32/3	96.2±.3	97.1±.4	97.1±.6	95.6±.4	93.4±.7	93.6±.8	94.5±.9	95.1±.5	94.9±.9

*output filter -3dB point = 4 kHz
**output filter -3dB point = 3 kHz

TABLE LXII. DAM SCORES OF SCHILLING CVSD SPEECH CODER 32 kb/s

TEST CONDITION	SPEAKER				
	CH	LL	JE	RH	JS
Optimum					
SCHIL 32/4	60.5	61.6			61.5
SCHIL 32/4	61.0	64.6			61.9
SCHIL 32/3	62.3	61.7			62.7
ERROR RATES					
.1% BER	62.5	60.2			58.5
1% BER	54.4	47.0			44.8
NOISE BACKGROUND					
Office	60.6		67.4	61.6	67.4
ABCP	60.2		62.8	60.8	
Helicopter	40.6		41.7	43.0	
DYNAMIC RANGE					
+6 dB	62.0	59.6			62.8
-12 dB	52.1	52.4			50.6
-20 dB	46.4	41.9			48.7
TANDEMS					
2X	60.5	56.8			56.7
3X	57.8	55.7			57.4
5X	52.1	53.7			46.2
LPC —— W	49.8	46.6			44.0
W —— LPC	46.1	48.2			41.5

TABLE LXIII. DRT SCORES OF SYLVANIA APCQ SPEECH CODER

TEST CONDITION	SPEAKER								
	LL	RH	CH	PK	JE	BV	JS	LS	MP
OPTIMUM	95.2±.6	94.5±1.0	91.4±.4	92.7±.7	91.0±.7	88.8±.7	90.6±.6	92.2±.6	91.1±1.5
ERROR RATES									
0.1% BER	92.4±.9	93.0±1.0					91.9±.7		
1.0% BER	87.0±1.6	88.5±.6					87.2±.8		
5.0%		63.9±1.0							
NOISE ENVIRONMENT									
OFFICE		94.1±.5					85.4±.9		
ABCP		89.1±.6			84.1±.9				
HELICOPTER		71.7±1.4			71.7±1.6				
DYNAMIC RANGE									
+6dB		96.4±.4							
-12dB		92.6±1.1							
-20dB		86.5±1.6							
TANDEMS									
2X		90.8±1.2							
3X		79.2±1.2							
5X		62.4±1.5							
LPC→ W	88.2±1.4	85.0±1.0					75.8±1.2		
W→ LPC	85.5±1.0	86.8±.8					73.7±1.3		
KY75→ W (Quiet)	76.3±.9		81.1±1.0						
KY75→ W (ABCP)			71.5±1.6		58.3±2.2				

TABLE LXIV. DAM SCORES OF SYLVANIA APCQ SPEECH CODER

TEST CONDITION	SPEAKER CH	LL	JE	RH	JS
Optimum	57.8	56.1			
ERROR RATES					
.1% BER	55.6	58.5			60.5
1% BER	43.7	36.0			40.6
5% BER	21.9	22.7			17.5
NOISE ENVIRONMENTS					
Office	55.2		58.5	57.7	57.6
ABCP	50.1		51.7	52.9	
Helicopter	44.4		43.6	40.0	
DYNAMIC RANGE					
+6 dB	56.8	61.5			59.7
-12 dB	55.6	55.4			54.9
-20 dB	54.9	51.3			51.1
TANDEMS					
2X	45.6	47.0			50.9
3X	38.5	39.5			41.2
5X	25.8	25.5			27.0
LPC —— W	46.1	43.1			41.4
W —— LPC	45.2	44.9			43.7

TABLE LXV. DRT SCORES OF LOG CVSD SPEECH CODER 16 kb/s

TEST CONDITIONS	SPEAKERS								
	LL	RH	CH	PK	JE	BV	JS	LS	MP
OPTIMUM	73.1±.6	77.7±1.1	77.5±1.3	68.5±.9	65.9±1.7	69.9±.6	71.7±.9	74.7±1.2	76.7±1.2
ERROR RATE									
.1% BER	84.1±1.1	84.2±1.0					78.0±1.4		
1% BER	76.3±.9	80.2±1.3					65.2±.9		
5% BER	59.8±1.4	64.2±1.4					50.1±2.0		
NOISE BACKGROUND									
OFFICE		87.9±1.1			80.5±.8				
ABCP		84.2±1.0			70.6±1.9				
HELICOPTER		73.8±1.5							
DYNAMIC RANGE									
+6 dB		94.5±.9							
-12dB		84.5±1.2							
-20dB		74.6±1.0							
TANDEM									
2X		90.9±.7							
3X		82.7±.6							
5X		74.1±1.1							
LPC→W		77.1±1.1							

TABLE LXVI. DRT SCORES OF LOG CVSD SPEECH CODER 32 kb/s

TEST CONDITION	SPEAKER								
	LL	RH	CH	PK	JE	BV	JS	LS	MP
Optimum	85.9±2.0	84.4±.8	83.1±1.0	79.8±1.2	77.5±1.4	81.2±1.0	81.5±1.2	81.8±1.2	78.8±1.1
ERROR RATE									
5 %	70.7±1.1	71.4±2.2					51.6±1.5		
TANDEMS									
5X	92.3±1.2								
LPC —— W	85.9±1.2								

TABLE LXVII. DRT SCORES OF GENERAL DYNAMICS CVSD SPEECH CODER

TEST CONDITION	SPEAKER								
	LL	RH	CH	PK	JE	BV	JS	LS	MP
Optimum 16 kb/s	78.5±1.6	78.9±1.6	77.5±1.2	71.9±1.8	67.4±1.7	71.6±1.7	75.7±1.6	72.8±2.4	74.9±1.3
Optimum 32 kb/s	87.4±1.1	85.7±.9	86.6±.9	78.5±1.6	77.6±1.4	83.1±.7	81.4±1.0	83.1±1.7	79.8±1.0
ERROR RATES									
5% BER 16 kb/s	68.5±1.2	69.0±.8					52.5±2.3		
5% BER 32 kb/s	73.8±1.1	76.7±1.3					58.1±.9		
TANDEM									
LPC — W 16 kb/s		75.4±1.3							

TABLE LXVIII. DAM SCORES OF LOG CVSD SPEECH CODER 16 kb/s

TEST CONDITION	SPEAKER CH	LL	JE	RN	JS
Optimum	52.0	48.9			48.6
	53.4	51.6			53.7
ERROR RATES					
.1% BER	45.1	48.3			42.1
1% BER	43.6	39.2			40.6
5% BER	33.1	27.3			26.7
NOISE BACKGROUNDS					
Office	53.8		60.8	54.0	53.5
ABCP	48.0		51.0	52.0	
Helicopter	37.8		38.3	42.9	
DYNAMIC RANGE					
+6 dB	50.1	48.2			50.2
-12 dB	43.7	43.4			42.9
-20 dB	39.2	37.3			36.9
TANDEMS					
2X	45.8	42.4			44.1
3X	45.5	53.6			42.7
5X	37.4	35.3			37.3
LPC —— W	45.6	43.1			39.6

TABLE LXIX. DAM SCORES OF LOG CVSD SPEECH CODER 32 kb/s

TEST CONDITION	SPEAKER RH	LL	JE	CH	JS
Optimum	62.1	55.4			56.8
ERROR RATES					
1% BER	45.3	48.7			61.1
5% BER	28.0	31.5			26.9
10% BER	18.3	25.5			20.1
DYNAMIC RANGE					
-20 dB	47.2	43.1			43.7
TANDEMS					
5X	44.3	45.6			46.3
LPC —— W	44.1	48.7			42.5

TABLE LXX. DAM SCORES OF GENERAL DYNAMICS CVSD SPEECH CODER

TEST CONDITION	SPEAKER				
	CH	LL	JE	RH	JS
Optimum					
CVSD GD 32 kb/s	61.4	63.8			64.4
CVSD GD 16 kb/s	53.2	47.6			50.0
ERROR RATES					
.1% BER CVSD GD16	44.4	41.1			42.4
1% BER CVSD GD32	46.4	50.1			45.5
CVSD GD16	43.3	39.2			41.7
5% BER CVSD GD32	27.9	30.8			24.8
CVSD GD16	24.6	30.0			24.3
10% BER CVSD GD32	29.2	26.1			21.5
TANDEMS					
3X CVSD GD16	39.2	37.7			40.7
5X CVSD GD16	34.6	38.9			38.0
LPC — W CVSD GD16	46.5	46.7			40.7

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APPENDIX A

MODEM Performance Tests

1. Introduction. A set of tests was conducted in order to evaluate the effects of processing MODEM line signals with the CVSD speech coder operating at 32 kb/s. Figure A.I shows the test configuration with the Codex 9600 MODEM. A bit error rate tester (BERT 901) was used to measure bit errors.

2. Test Conditions. The Schilling CVSD Speech coder operating at 32 kb/s was used to process the MODEM line signals. Tests were conducted using different audio bandwidths of the CVSD coder. Tests were also conducted under conditions of transmission bit errors. The Codex MODEM was tested for three data rates, 4.8 kb/s, 7.2 kb/s, and 9.6 kb/s.

3. Performance Measurements. The MODEM performance was measured according to bit errors. In each test the number of bit errors and the number of block errors were determined. A block error is defined as a specified number of bit errors per block of data. In addition, the MODEM indicator light showed the operating condition of the MODEM.

4. 4.8 kb/s Test Results. Table A.I shows the measured bit error rates and block error rates for the Codex 4800 b/s MODEM. The error rates are given corresponding to different transmission bit error rates produced by an error generator that introduces bit errors into the CVSD transmission data stream. The cutoff frequency of the CVSD audio filter was varied from 2.0 to 6.0 kHz. A block error is defined as 3 bit errors within a data block of 1000 bits. MODEM performance was satisfactory for transmission bit error rates of 10^{-4} and less. However, performance was marginal for a transmission BER of 10^{-3}. In this case the block error rate was 0.137 and the MODEM indicator light showed a marginal operating condition.

The results indicate that the MODEM performance is insensitive to the different audio bandwidths of the particular audio filter tested.

5. 7.2 kb/s MODEM. Table A.II shows the measured bit error and block error rates of the Codex MODEM operating at a data rate of 7.2 kb/s. These measurements were made under conditions of two different CVSD transmission error rates. The performance of the MODEM was marginal.

6. 9.6 kb/s MODEM. Table A.III shows the measured bit error rates of the Codex MODEM operating at 9.6 kb/s. The performance of the MODEM operating at this rate was unsatisfactory.

7. Summary. For satisfactory processing of the Codex 4.8 kb/s modem line signals, the data rate of the CVSD coder must be at least 32 kb/s. The bit error rate of the CVSD data link should be less than 10^{-4}. Operating the modem at 7.2 kb/s resulted in a marginal to unsatisfactory link. Operating the modem at 9.6 kb/s resulted in an unsatisfactory link.

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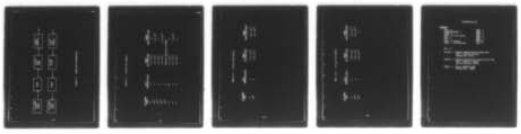

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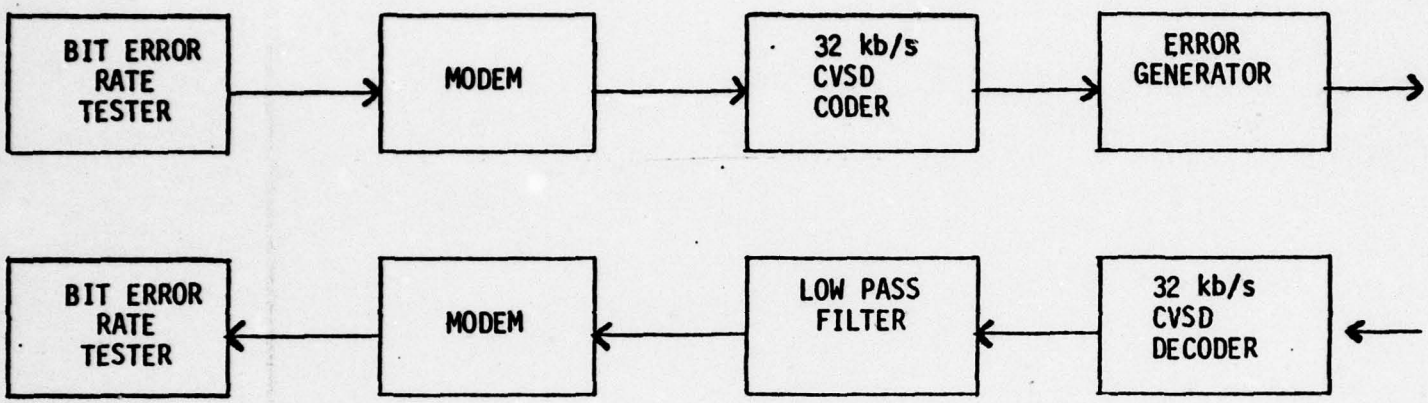

FIGURE A.I MODEM TEST CONFIGURATION

TABLE A.I. 4.8 kb/s TEST RESULTS

BIT ERROR RATE	LPF BANDWIDTH (kHz)	MODEM BIT ERROR RATE	MODEM BLOCK ERROR RATE
0	4	4.7×10^{-5}	0
10^{-6}	4	5.4×10^{-5}	4×10^{-4}
10^{-5}	4	7.0×10^{-5}	0
10^{-4}	4	7.5×10^{-5}	1.2×10^{-3}
10^{-3}	4	Marginal Operation of MODEM	
0	25	3.7×10^{-5}	0
0	2	4.3×10^{-5}	4×10^{-4}
0	6	4.3×10^{-5}	0

TABLE A.II. 7.2 kb/s TEST RESULTS

BIT ERROR RATE	LPF BANDWIDTH (kHz)	MODEM BIT ERROR RATE	MODEM BLOCK ERROR RATE
0	4	5.17×10^{-3}	8.9×10^{-2}
10^{-6}	4	5.19×10^{-3}	9.6×10^{-2}

TABLE A.III. 9.6 kb/s TEST RESULTS

BIT ERROR RATE	LPF BANDWIDTH (kHz)	MODEM BIT ERROR RATE	MODEM BLOCK ERROR RATE
0	4	2.58×10^{-2}	9.9×10^{-1}
10^{-6}	4	2.54×10^{-2}	9.8×10^{-1}
10^{-4}	4	3.95×10^{-2}	1

DISTRIBUTION LIST

STANDARD:

R100 - 2
R102/R103/R103R - 1
R102M - 1
R102T - 9 (8 for stock)
R104 - 1
R110 - 1
R123 - 1 (Library)
R124A - 1 (for Archives)
R200 - 1
R300 - 1
R400 - 1
R500 - 1
R700 - 1
R800 - 1
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101A - 1

205 - 13

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APO San Francisco 96515)

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